V. Water Quality Assessment Process

The water quality assessment process in Tennessee consists of three parts:

1. Development of clean water goals.

2. Development and implementation of a statewide water quality monitoring program.

3. Comparison of data to water quality standards in order to place each waterbody into the proper assessment category.

A. Water Quality Standards

The Tennessee Water Quality Control Act requires the protection of water quality and the designated uses as defined in Tennessee's water quality standards (Tennessee Department of Environment and Conservation, 1999). Tennessee standards have three sections. The first section establishes seven designated uses for Tennessee waterways. All surface waters have at least four basic uses: fish and aquatic life, recreation, irrigation, and livestock watering and wildlife. The second section establishes water quality criteria to protect the designated uses. The final section is an antidegradation policy designed to protect established water uses and prevent future damage to water quality.

Because streams are generally classified for multiple uses and may have multiple criteria for each substance, the most stringent criteria must be met. The combination of classified uses, the most stringent criteria for those uses, and the antidegradation policy provisions create the water quality standards for each stream segment.

Classification + Criteria + Antidegradation = Standards

1. Stream-use Classification

Tennessee has approximately 60,000 stream miles and 536,000 publicly owned lake acres. All the streams and lakes are classified for at least four public uses: protection of fish and aquatic life, recreation, irrigation, and livestock watering and wildlife. This minimum standard is consistent with the national goal that all waters provide for the "protection and propagation of…fish and wildlife…and allow recreational activities in and on the water".

Current Stream-Use Classifications:

1. Fish and aquatic life
2. Recreation
3. Irrigation
4. Livestock watering and wildlife
5. Drinking water supply
6. Navigation
7. Industrial water supply

The Tennessee Water Quality Control Board is responsible for the designation of beneficial uses of all waterbodies. Most streams are classified for fish and aquatic life protection, recreation, irrigation, and livestock watering and wildlife. The drinking water supply designation is generally assigned to waterbodies currently or likely to be used as domestic water sources in the future. The navigation and industrial water supply classifications are generally limited to waters currently being used for those uses, but can be expanded to other waters as needed.

Designated uses are goals, not necessarily the current use of that waterbody. Even if a stream or reservoir is not currently used for a given activity, it should still be protected for that use in the future. As Tennessee's population continues to expand, more stress is placed on all natural resources. A safe sustainable water supply is essential for the state's social and economic development.

a. **Fish and Aquatic Life (FAL) -** FAL criteria protect aquatic life. These criteria consist of two types of toxicity. One is acute toxicity. It refers to the level of a contaminant that causes death in organisms in a relatively short time. The other type is chronic toxicity. In chronic toxicity, a lower level of a contaminant causes death over a longer period of time or has other effects such as reproductive failure. Some of these criteria are specific to trout waters due to the sensitivity of trout species. Trout waters are specifically noted in the regulation.

b. **Recreation -** These criteria protect the use of streams for swimming and fishing. They include criteria designed to prevent elevated bacteria levels in the water. Historically, fecal coliform has been used as the indicator of contamination in streams. In 1997, the Division began a shift towards using *E. coli* as the primary indicator of pathogens in streams. The current *E. coli* criterion is 126 colonies per 100 ml of water, as a geometric mean of ten or more samples.

Another provision of recreational criteria is the prevention of the accumulation of dangerous levels of metals or organic compounds from the water or sediment that may eventually accumulate in fish tissue. Additionally, the Water Quality Control Act suggests that streams be posted if swimming or fishing poses an unacceptable risk to human health. Additional information about fishing advisories is provided in Chapter IX.

Some of the most valuable uses of our waterways are related to recreational activities. Old Hickory Reservoir (Photo by Debbie Arnwine, Planning and Standards.)

c. Irrigation - Irrigation criteria protect the quality of water so it may be used for agricultural needs.

d. Livestock Watering and Wildlife - These criteria protect wildlife and farm animals.

e. Drinking Water Supply – Drinking water criteria insure that water supplies contain no substances that might cause a public health threat, after conventional water treatment. Since many contaminants are difficult and expensive to remove, it is more cost effective to keep pollutants from entering the water supply in the first place.

f. Navigation – Criteria designed to protect navigational rivers and reservoirs from any alterations that would adversely affect commercial uses.

g. Industrial Water Supply - These criteria protect the quality of water used for industrial purposes.

Specific designated uses for surface waters in Tennessee are listed in Rules of TDEC, Chapter 1200-4-4 (Tennessee Department of Environment and Conservation, 1999). All surface waters that are not specifically listed in the regulations are classified for fish and aquatic life, recreation, irrigation, livestock watering and wildlife.

A copy of this regulation can be viewed or downloaded at the Tennessee Secretary of State's Homepage. There is a link to this site from the department's home page:

http://www.state.tn.us/environment
or
(http://www.tdec.net)

2. Water Quality Criteria

The Water Quality Control Board has assigned specific water quality criteria to each of the designated uses. These criteria establish the level of water quality needed to support each of the designated uses. There are two types of criteria:

a. **Narrative criteria** are written descriptions of water quality. These descriptions generally state that the waters should be "free from" particular types or effects of pollution.

b. **Numeric criteria** establish a measurable safe level for pollutants.

All streams are classified for at least four uses. The regulations require that the most stringent criteria be applied as the clean water goal for that stream. Typically, the most stringent criteria are the protection of either aquatic life or recreational uses.

General water quality criteria for surface waters in Tennessee are listed as part of a specific regulation: Chapter 1200-4-3. A copy of this regulation can be viewed at the Tennessee Secretary of State's Homepage. There is a link to this site from the Department's homepage:

http://www.state.tn.us/environment

Since Tennessee does not perform primary research into the adverse effects of pollutants, reliance is placed on EPA for this information. EPA's standards are usually based on the following research:

- Toxicity tests performed on lab animals.
- The number of cancer incidences occurring in laboratory animals after exposure to a substance.
- The tendency of a substance to concentrate in the food chain.

The water quality criteria provide numeric or narrative descriptions of the level of water quality necessary to support classified uses.

3. Antidegradation

The final section of Tennessee water quality standards is an antidegradation statement. This portion of the law protects existing uses of all surface waters. The antidegradation standard protects both high quality streams and streams that have been impacted by pollution. This section of the law also provides for the highest level of protection for Tennessee Outstanding National Resource Waters (ONRW). Tennessee has designated eight ONRWs. Table 1 illustrates the level of protection afforded to different classifications of water.

Table 1: Antidegradation Categories.

Category	Protections
Tier I	Most waters of the state are Tier I. Existing uses will be maintained by application of the general water quality criteria. Additional loadings of pollutants cannot be allowed if the water quality standard of a stream is currently being violated. Degradation can be allowed in some Tier I streams, but only if non-degrading alternatives are generally unavailable. Degradation must be in the public's interests.
Tier II	High quality waters in which no degradation will be allowed unless and until it is demonstrated that a change is justifiable as a result of necessary economic or social development and will not interfere with or become injurious to any classified uses existing in such waters. Degradation in Tier II streams can only be authorized by the Tennessee Water Quality Control Board.
Tier III (Outstanding National Resource Waters)	These high quality waters constitute an outstanding national resource, such as waters of national and state parks, wildlife refuges and waters of exceptional recreational or ecological significance. No degradation will be allowed in these waters.

B. The Assessment Process

The water quality assessment data in this report summarize of how well the streams in Tennessee meet their assigned water quality standard. To facilitate this analysis, all major rivers, streams, reservoirs, and lakes have been divided into sections called waterbody segments. Assessed waterbodies were placed in one of five categories:

1. **Fully Supporting** waterbodies have water quality that will support its designated uses. Most streams in Tennessee fall into this category. Water quality criteria are generally always met in these streams. Additionally, they support a level of biological integrity generally comparable to that found in reference streams in the same region.

2. **Fully Supporting but Threatened** are those waterbodies that, if current trends continue, will loose the ability to support designated uses in the next two years. This assessment must be supported by data indicating a pattern of water quality degradation.

3. **Partially Supporting** waterbodies are moderately impacted by pollution and water quality criteria are violated on a regular basis. Water quality is considered somewhat impacted. Significant differences may be noted between biological communities at partially and fully supporting streams.

4. **Not Supporting** waterbodies are highly impacted by pollution. Water quality criteria are frequently violated. Water quality is considered severely impacted. Substantial differences in biological communities are noted when compared to fully supporting streams.

5. **Not Assessed** are waterbodies where recent water quality data are not available. Rather than make an assessment in which the Division would have low confidence, streams are placed in this category.

Types of Assessments

Evaluated rivers and lakes were assessed using data more than five years old, or were based on special data, such as land use, watershed information, or predictive models. Very few of Tennessee's assessments are based on evaluations.

Monitored rivers and lakes were assessed using current (less than five years old) data, including fixed-station ambient, intensive surveys, NPDES compliance sampling, or biological monitoring.

According to EPA guidance, assessments can either be based on recent data (monitored) or other types of information (evaluations). TDEC strongly prefers to base stream assessments on recently collected data as judgments based on modeling or land use are much harder to defend. Very few of Tennessee's water quality assessments are evaluations.

It is not possible to monitor all of Tennessee's streams during the two years covered by this report. Some streams are very difficult to access. Others are very small with intermittent flows. During periods of low flow, many of these streams may be dry.

A strategy based on the watershed cycle has been designed and implemented to systematically sample and monitor as many streams as possible. Rivers and lakes are assessed separately. For example, the Tennessee River is no longer a free-flowing river, but rather, is a series of reservoirs. For this reason, it is included under reservoir information.

For this report, 48.8% (29,406 miles) of the stream miles (Figure 4) and almost all of the lake acres (Figure 5) in the state were assessed for existing water quality. 30,820 miles of Tennessee's streams could not be assessed during this cycle. However, it should be noted that most of the larger rivers and streams have been assessed.

The Division continues to increase its reliance on rapid biological assessments. These assessments provide a quick and accurate assessment of the general water quality in a stream. However, biological assessments do not provide information to pinpoint specific toxic pollutants or bacterial levels in water.

The challenge in the next few years will be to combine biological assessments with chemical and bacteriological data so that both use support status and accurate cause and source information can be generated.

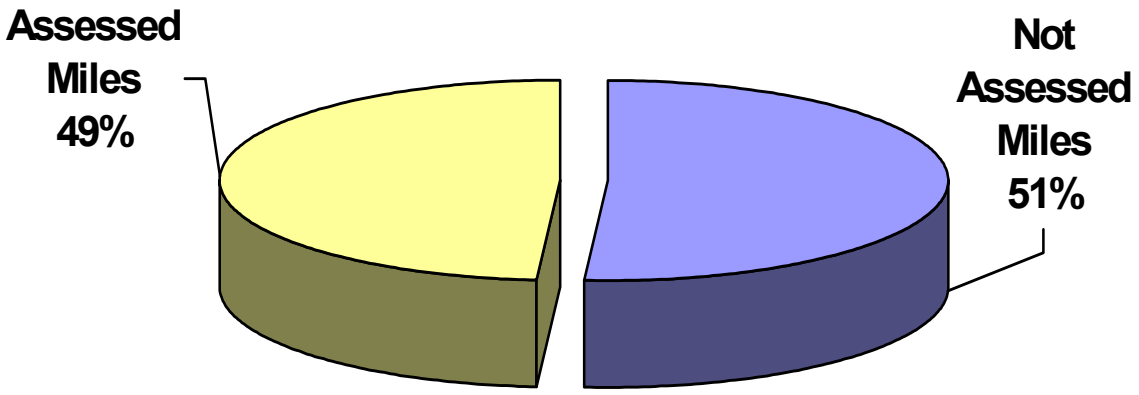

Figure 4: Percent of Rivers and Stream Miles Monitored

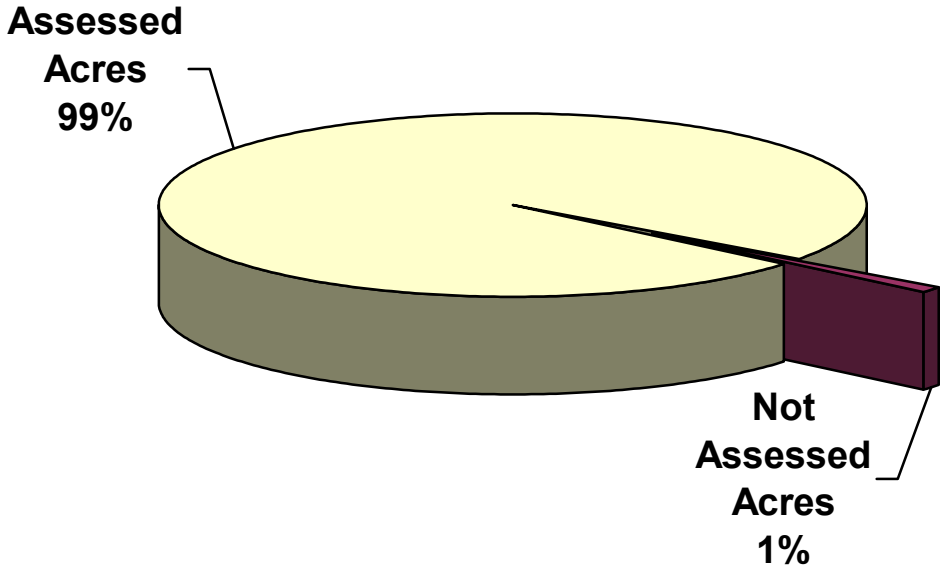

Figure 5: Percent of Reservoir and Lake Acres Monitored

1. Data Sources

The division uses all reliable data gathered in the state for the assessment of Tennessee's waterways. This includes data from TDEC as well as other state and federal agencies and private organizations (Table 2). In December of 2001, the division issued a public notice requesting water quality data for use in this water quality report. Information regarding Tennessee's water quality was received from EPA, TVA, USGS, OSM, TWRA, USCOE.

EPA has developed an updated version of the national STOrage and RETrieval database called STORET. This recently updated database allows for easy access to chemical information collected throughout the state. Currently, TVA, USCOE, OSM, and USGS are not using the STORET database. Therefore, these agencies were contacted directly for additional information.

2. Data Analysis Tools

The Division has several tools that have increased the efficiency and accuracy of assessments. Modern high-speed computers combined with new software have greatly expanded the ability to accurately assess water bodies. These improvements have helped not only with the organization of large quantities of information, but also analysis of specific water bodies.

The STORET database is used to access water quality information. The new version is easier and faster to use and should continue to improve the efficiency of water quality assessments.

Data Analysis Tools

- STORET
- ADB
- GIS
- RIT

The **Assessment Database (ADB**) used by the Division was developed by EPA to store and retrieve assessment information on individual stream and lake segments. The ADB allows for specific analysis of small stream segments, as well as, overall assessments of total watersheds. The ADB system is linked to the **Geographic Information System (GIS)**. The combination of these technologies allow for easy assess to information on specific streams by merely locating them on the GIS map.

EPA also developed the **Reach Indexing Tool (RIT)**. This software is linked to the ADB and GIS allowing quick georeferencing of assessment information. The RIT can produce maps of specific stream information. It is the Division's goal in the near future to have the ADB, the GIS, and the RIT available to the public on the website. Maps of assessment information at the watershed level are available at the department's home page: (http://.state.tn.us/environment).

Table 2: Types Of Data Used in the Water Quality Assessment Process

Chemical Data	Biological Data	Physical Data	Sediment And Tissue Data
Compliance monitoring performed at the nearly 2,000 permitted dischargers in Tennessee. Data collected as a result of complaint investigations, fish kills, spills, and in support of enforcement activities.	Rapid biological surveys completed in association with the watershed project. These were performed primarily in tributary streams as a means of monitoring biological integrity.	Temperature and flow data collected throughout Tennessee.	Sediment and fish tissue data collected at various sites across Tennessee.
Ambient data collected at over 355 fixed-station monitoring sites. Also, over 2,500 stations were established to support the Watershed approach.	Ecoregion biological monitoring. Benthic and fish IBI scores calculated at many sites.	Quantitative assessments of habitat made in conjunction with biological surveys.	EPA's report The Incidence and Severity of Sediment Contamination in Surface Waters of the United States.
Data collected at the Division's 100 ecoregion reference sites. (These stations provide a baseline to which other sites within that ecoregion can be compared.)	Bioassay studies of effluent toxicity at most major NPDES dischargers. Many minor facilities also do this type testing.	Time-of-travel studies of flow, dissolved oxygen sags and BOD decay rates.	Locations of existing fishing advisories in Tennessee.
Chemical data collected by other agencies*.	Biological data collected by other agencies*.	Physical data collected by other agencies*.	Sediment and tissue data collected by other agencies*.

* The Division of Water Pollution Control is grateful to the following agencies for providing their monitoring data and reports: U.S. Environmental Protection Agency (STORET, sediment report, Index of Watershed Integrity); Tennessee Valley Authority biological data, Reservoir Vital Signs Monitoring, NPDES discharge monitoring, recreational area fecal coliform sampling, tailwater monitoring; Tennessee Wildlife Resources Agency (biological surveys and fish tissue monitoring data); U.S. Geological Survey (gaging station data); U.S. Army Corps of Engineers (water, sediment, and tailwater monitoring), and U.S. Fish and Wildlife Service (species databases).

3. Data Use

The Division's goal is to make assessments more numerically quantifiable (objective) and therefore require less professional (subjective) judgment.

WPC is accomplishing this goal as follows:

a. The ecoregion project has dramatically reduced the uncertainty associated with the application of narrative criteria.

b. Data from a sampling point are extrapolated a much shorter distance than in the past. The decision on how far the information is applicable is made on a site-by-site bases using factors such as amount and type of data and the uniformity of the stream.

c. Minimum data requirements for the specific types of data have been set.

d. Certain collection seasons and types of data have proven more important for the protection of specific water uses. For instance, the critical period for parameters like toxic metals or organics is the low flow season of late summer and early fall. Other activities like swimming and wading are mostly likely to occur in the summer.

4. Data Application

Tennessee's water quality standards assign specific water quality criteria to each of the use classifications. Two types of criteria are established in Tennessee's regulation. Numeric criteria establish specific levels for conditions or constituents in water. Narrative criteria state that the water should not have particular types or effects that indicate loss of use support.

Water quality assessment is simply the application of water quality criteria to the ambient data previously collected. However, several factors complicate this process:

- Narrative criteria provide only descriptions of conditions that either comply with, or violate, the water quality standards. The Division is left to interpret what these acceptable levels are.

- In order to make defensible assessments, data quality objectives must be met. For some parameters, a minimum number of observations must be established in order to have confidence in the accuracy of the assessment.

- Provisions in the water quality criteria instruct staff to determine whether violations are caused by man-induced conditions or natural conditions. Natural conditions are not considered to be pollution.

- The magnitude, frequency, and duration of violations must be considered in the assessment process.

- Many streams in Tennessee experience periodic dryness. It can be a challenge to determine if changes in biological integrity are related to man induced conditions or simply that the stream was recently dry.

In order to address these issues and concerns, the division has developed an assessment strategy. This strategy is summarized in the following section.

Environmental Specialist Michael Robbins collects water samples for chemical analysis. When the Division assesses these data, the natural background conditions of streams in that region will be factored into the conclusions. (Photo by Dan Murray, Mining, Knoxville EAC)

a. Parameters with Numeric Criteria

Metals and Organics Guidance

- One or two chemical samples are not considered an accurate representation of stream conditions. Therefore, more than two observations were used in all assessments. Acute fish and aquatic life protection criteria were generally used unless a site had 12 or more chemical collections. If a site had 12 or more chemical collections, chronic criteria could be applied.

- All metals data are appropriately "translated" according to the water quality standards before comparison to criteria. For example toxicity of metals is altered by stream hardness and the amount of total suspended solids in the stream. Widely accepted methodologies are available to make these and other translations of the data.

Bacteriological Guidance

- Streams will not be assessed as impacted due to high bacteria levels with less than three water samples. The only streams assessed with one or two observations are streams previously listed due to elevated bacteria levels.

- E. coli data are generally considered more significant than fecal coliform data.

- If flow data are available, low flow, dry season data are considered more meaningful than high flow, wet season data. In the absence of flow data, samples collected in late summer and fall are considered low flow or dry season samples. It is important to note that wet season pathogen samples are not disregarded. They are simply given less weight than dry season pathogen samples.

b. Parameters with Narrative Criteria

Nutrients

- One or two chemical collections are considered a valid assessment only if they are supported by evidence of biological impairment. For example, if the biology of a stream is very poor and the amount of algae present indicates organic enrichment, then one or two chemical collections could be used to identify a suspected cause of pollution.

- Regional nutrient goals were developed and used during this assessment cycle. (Denton et al., 2001). The Division intends to recommend promulgation of these goals as specific water quality criteria during the next triennial review of water quality standards.

Suspended Solids/Siltation

- Historically, silt is one of the primary pollutants in Tennessee surface waters. The division has experimented with multiple ways of collecting sufficient data to determine stream impairment due to siltation. These methods include visual observations (dirt in the water), chemical analysis (total suspended solids), and macroinvertebrate/habitat surveys. Biological surveys that include a habitat assessment have proven to be the most satisfactory method.

- Through work at reference streams, staff found that the appearance of dirt in the water is often, but not always, associated with loss of biological integrity. Additionally, the various ecoregions are very dissimilar in the amounts of silt that can be tolerated before aquatic life is impacted. Thus, for water quality assessment purposes, it is good to establish whether or not aquatic life is being impacted. For those streams where loss of biological integrity can be documented, the habitat assessment can easily determine if the stream has excessive amounts of silt.

- The division has published a study of habitat quality at reference streams (Arnwine and Denton, 2001). This guidance is used as a guide for wadeable test streams within the same region.

Biological Data

- Biological surveys using macroinvertebrates as the indicator organisms are the preferred method for assessing support of the fish and aquatic life designated use. Two standardized biological methods, biorecons and semi-quantitative samples, are used to produce a biological score or biological index (TDEC, 2002).

- The most commonly utilized biological surveys are biorecons. Biological scores are compared to the metric values obtained in ecoregion reference streams. The principal metrics used are the number of mayflies, stoneflies, and caddisflies (EPT) families (or genera), the total families (or genera), and the number of pollution intolerant families (or genera) found in a stream.

- If a more definitive assessment is needed, a single habitat, semi-quantitative sample is collected. Organisms are identified to genus, and an index based on seven metrics is used for comparison to ecoregion reference streams.

- Streams where biological integrity does not fall within the expected range of conditions found at reference streams, are considered impacted. (Note: the stream being compared to the reference stream database and sampling techniques must be similar for this methodology to be valid.)

- If the data from the Division and another agency do not agree, more weight is given to the Division's data unless the other agency's data is considerably more recent.

- Regional numeric goals for biological integrity have been developed and were used during this assessment cycle. (Arnwine and Denton, 2001). The Division intends to recommend promulgation of these goals as specific water quality criteria during the triennial review of water quality standards.

Habitat Data

- Division staff use a standardized scoring system developed by EPA to rate the habitat in a stream.

- Habitat scores calculated by Division biologists are compared to the ecoregion reference stream database. Streams where habitat scores are not within 75 percent of the median reference score are considered impacted. However, streams are not assessed as habitat impacted if the documented biological integrity meets expectations.

- Guidance on the interpretation of the narrative habitat criterion has been developed and was used during this assessment cycle (Arnwine and Denton, 2001).

Amy Fritz of the Jackson EAC sorts through the invertebrates she just collected in Pompey Branch near Pickwick Lake. Pompey Branch is a reference stream for subecoregion 65j. (Photo by Pat Patrick, Jackson EAC.)